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Satellite Telemetry & Command Using Big LEO Mobile Telecommunications Systems

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Objective

- Use Commercial Global Satellite Mobile Telecommunications Systems (Big LEOs) to provide Telemetry and Command Services to user satellites in LEO
 - The user spacecraft's transceiver would be a space qualified version of the systems User Terminal (mobile phone)
- Globalstar, ICO and Iridium have been studied

Targeted Capabilities

- Provide real time contact to LEO user satellites with a simple phone call
- Provide the capability for the satellite to "phone home"
- Command and telemetry data rates of 8K bits/sec
 - Higher rates with data compression
- At least one 5 minute contact per orbit
- Small, low power, low cost transceiver
- Simple omni antenna system
- Secure link

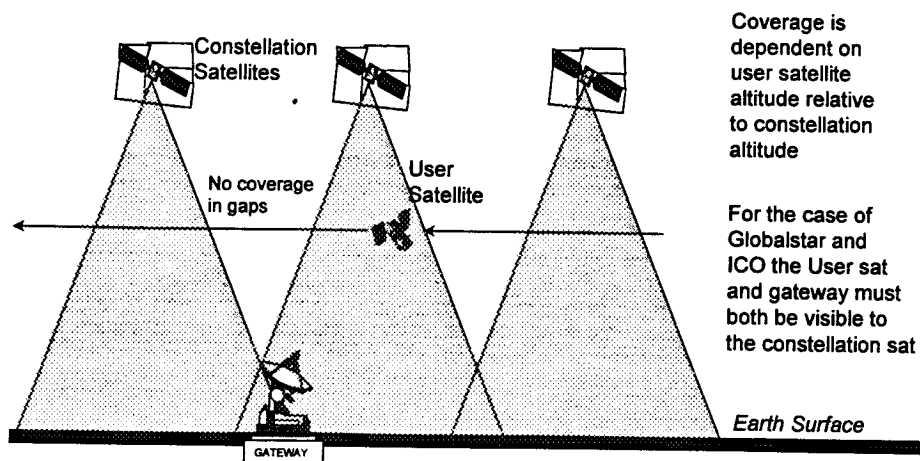
Rational - Make use of the Billions of \$ of privately funded infrastructure to provide :

- Reduced Mission Communications System Cost
 - Reduces or eliminates the cost of ground stations and associated infrastructure
 - Eliminates the need for frequency assignments
 - Low cost transceiver, small size, low mass and low power
- Flexibility in Science Operations
 - Event monitoring and immediate reporting
 - Quick look data evaluation
 - Several Contacts per orbit possible
 - Real time access to user satellites from remote locations

Communications Satellite Constellations Studied

- Globalstar - LEO - operational in mid 99
- Iridium - LEO - operational mid 98
- ICO Global Communications - MEO - operational in mid 2000

Contact Limitations



Capabilities - Iridium

- The fairly low constellation orbit (780 KM) precludes significant coverage of user satellites
 - In general contacts are very short with large coverage gaps
 - Polar orbiting user satellites are an exception - adequate coverage is available in this case due to co-orbiting of the user sat with the constellation satellites
 - Data rates limited to 2400 bits/sec
- Possible use of crosslinks has been investigated
 - Could provide excellent coverage and Mbit/sec data rates
 - User Satellite would "take over" the intersatellite link
 - Technically feasible but not deemed operationally feasible by Iridium

Capabilities - ICO Global

- Excellent coverage for orbits up to 900 km
 - One 10 to 30 minute contact per orbit using only one gateway
 - Optimal coverage at 52° inclination
- Front end Doppler compensation required
- Data rates limited to 2400 bits/sec

Capabilities - Globalstar

- Good coverage for orbits up to 600 Km with inclinations up to 57°
 - The lower the orbit the better the coverage. Optimal coverage at 52° inclination
 - Better than one contact per orbit at 400 km using 4 gateways
 - contacts range from 5 to 18 minutes, the average is 11 minutes at 400 Km, 52° inclination
- No front end Doppler compensation required
 - Range rate between Globalstar satellite and user satellite no greater than that experienced for a user on the Earth's surface 90% of the time

Globalstar (Continued)

- Data rates up to 8 Kbits/sec possible
- At an orbit of 400km, 52° inclination
 - Total contact time per day is about 264 minutes
 - Total downlink per day is 127 Mbits
 - Average outage time is 56 minutes
- Initial feasibility study with Globalstar/Space Systems Loral completed 12/96
 - System issues identified
 - Link analysis performed
 - No show stoppers identified

Globalstar Link Analysis

- Assumptions

- Omnidirectional coverage required
- Coverage over full Globalstar FOV (108°)
- Eb/No requirement as specified in FCC filing
- Maximum link range used for a user satellite in a 300 Km altitude
- Single Globalstar in view (no signal combining)
- Maximum transmission rate of 9.6 kbps
- On average during a pass 0 dB of additional dynamically supplied additional power required.

- Link closes under the following conditions

- Transmit switch used rather than splitter
- Low loss cabling used (Gore ~ 0.2dB/Ft)
- Low noise amplifiers are located at the antennas

Globalstar Issues

- Protection of Radio Astronomy Sites (RAS)

- Sensitive in the 1610.6 MHz to 1613.8 MHz range (Globalstar return link)
- Requires operation at the upper end of the assigned L Band frequency range as well as the use of a transmit band reject filter
- Or restrict operations when near an active RAS site (reduces potential contact opportunities)

- Location information required

- Normal call handling procedures require the location of the user
 - This is normally determined by the Globalstar system but will not work for Space applications
- Location can be determined by on board ephemeris or GPS and entered into the transceiver

Flight Transceiver

- **Derivative of fixed User Terminal**
 - easily adaptable for position input
 - Control and data interface to the spacecraft C&DH
- **Size and weight are driven by the band reject filter**
 - Approximate size 8 by 6 by 3 inches
 - Approximate weight is 7 pounds
- **Power**
 - Standby, 1.5 watts
 - Transmit, 20 watts

Security

- **Gateway to User Satellite**
 - CDMA inherently secure (spread spectrum system)
 - Encryption of traffic channels part of Globalstar baseline
- **Ground segment**
 - Call acceptance filtering by ground system blocks unauthorized calls
 - Phone numbers can be re-assigned if necessary
 - Use of unlisted phone numbers

Conclusions

- Feasibility study with Globalstar indicates that spacecraft command and telemetry through commercial telecommunications satellite constellations is feasible with little or no modifications to the system architecture
- The user would connect to their spacecraft via telephone/modem
- Frequent contact opportunities would be available
- Data rates are limited but adequate for command/telemetry and quick look science
- Further studies of the Globalstar and ICO systems are needed to better define the capabilities, limitations, and system impacts of the Space Mobile Service

Key Benefits

- Facilitator for low cost LEO missions such as University Explorers (UNEX), Small Explorers (SMEX) and others
 - Could provide significant savings per mission
 - Users pay only monthly access fee and per minute charges
- Provides flexibility and simplification in mission operations
 - Enhanced access to spacecraft

Session 3

Architectures and Network Simulations